

13.3 Refraction

Name: _____ Class: _____ Date: _____

Total: 10 marks

Objective

Build the skills to answer exam questions on **refraction**.

You must be able to:

- explain **refraction** 折射 as a change in the speed and direction of light at a boundary
- apply **Snell's law** 斯涅尔定律 $n_1 \sin \theta_1 = n_2 \sin \theta_2$ using the index of refraction
- describe **total internal reflection** 全内反射 and calculate the critical angle

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Refraction

Light changes **speed** at a boundary, so its direction bends —toward the normal entering a **denser** medium (higher n).

■ Snell's law

$n_1 \sin \theta_1 = n_2 \sin \theta_2$, with the angles measured from the normal.

■ Total internal reflection

Going from dense to less dense, beyond the **critical angle** ($\sin \theta_c = n_2/n_1$) all the light reflects back inside.

2 Practice

2.1 Light passes from air ($n = 1.0$) into glass ($n = 1.5$) at 40° to the normal. Find the angle of refraction. [2]

2.2 State what happens to the speed of light entering a denser medium. [1]

2.3 State the condition for total internal reflection to occur. [1]

3 Exam-style questions

3.1 Snell's law is [1]

- **A** $n_1 \sin \theta_1 = n_2 \sin \theta_2$
 - **B** $n_1 \theta_1 = n_2 \theta_2$
 - **C** $\sin \theta = n$
 - **D** $n = c/v$ only
-

3.2 Total internal reflection occurs when light travels [1]

- **A** from less dense to more dense at any angle
 - **B** from more dense to less dense above the critical angle
 - **C** exactly along the normal
 - **D** through a vacuum
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3.3 Light passes from water ($n = 1.33$) toward air ($n = 1.0$).

(a) Find the critical angle. [3]

(b) State what happens to light striking the surface above this angle. [1]

4 Go further

- work through the **13.3 Refraction** lesson on the **Learn** page;
- read the **Geometric Optics** section of the AP Physics 2 handout on the **Know** page.

Solutions

2.1 $\sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2} = \frac{1.0 \sin 40^\circ}{1.5} = 0.428 \Rightarrow \theta_2 = 25^\circ.$

2.2 it decreases.

2.3 the light must go from a denser to a less dense medium at an angle above the critical angle.

3.1 A.

3.2 B.

3.3 (a) $\sin \theta_c = \frac{n_2}{n_1} = \frac{1.0}{1.33} = 0.752 \Rightarrow \theta_c = 48.8^\circ.$ (b) it is totally internally reflected.